ANNUAL REPORT OF

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

FOR 1942

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A REPORT OF ACTIVITIES AT THE INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION DURING THE WAR YEAR 1942

Changes made in our station program during the first year of war have been analyzed and evaluated and we believe our reorientation to meet war needs has been successful. Most of our time and means have been expended to further the Department's program of increased food and fiber production and particularly that phase calling for more meat, hides, and wool. Only those parts of our regular research program that would contribute importantly to the new objectives, or were supplying records necessary to prevent irrecoverable loss of past investments in time and money were continued. But even in this short-time program we have kept in mind our broad, long-time objectives of conservation.

During the past year our efforts were spent principally in compilation and analysis of data obtained from past research, and in facilitating certain war programs of range livestock operators and government agencies.

In addition to working with national forest supervisors and stockmen concerned with range management, reseeding, and production of meat and wool, we have given considerable time and energy to special problems arising out of war programs. We have participated in the Department's War Board activities, the Agricultural Adjustment Agency's production and conservation program, and in the formulation of production goals for the states and counties in our region. Also we have consulted with and furnished data to the Army Engineers in connection with their planning and constructing military establishments in Utah on critical matters of water supply, flood control, and conservation. We developed plans and supervised work in reseeding sand- and dust-producing areas at the Ogden Arsenal which were slowing up ordnance production. This job alone required more than 8 man-months of our time. We are now preparing a handbook for use by the Army in its soil stabilization and camouflage work connected with establishment of war industries and military camps in the arid West.

We also cooperated with the Utah Agricultural Extension Service in demonstrations, tours, and other educational programs to promote production of more feed for livestock through reseeding of depleted ranges and improvement of irrigated pastures.

Demands for our help in the food and wool production and other war programs in this coming year will be much greater. Because of our past experience and the progress we are making in synthesizing and organizing the results of our past research which is now being organized for publication, we will be able to serve much more effectively this important need during 1943.

In the following pages is an appraisal of some of the work that we have done during the last year with a running account of certain accomplishments and conclusions, as well as plans for the future.

RANGE INVESTIGATIONS

Range research during 1942 was concentrated primarily on those phases of work that would contribute most directly and immediately to the production of essential war commodities--meat, wool, and hides. This emphasis necessitated considerable modification of our regular research activities, resulting in suspension of certain phases, acceleration of others such as assembling desirable data and writing manuscripts, lending aid and guidance to reseeding programs, and developing procedures and criteria for more accurately determining range condition.

Activities under the various projects, with a brief summary of the findings that are of significance to the present objectives of greater forage production, together with plans for next year, are reviewed below.

SUMMER RANGE

Field work on most parts of the Summer Range Project at the Great Basin Branch Station has been suspended for more than 2 years so as to permit the completion of analysis and publication of data collected over a number of years.

Under our reoriented program the natural revegetation work has been laid aside and Ellison's efforts have been directed toward better grazing management on national forests, a study cooperatively conducted with Croft from the Division of Influences. A problem analysis presenting the need for this cooperative study is here included under the heading "Range-Watershed Condition Studies."

Jack Major's time was spent in the collection and analysis of phenological and ecological data which we felt should be continued because of the loss that would result from a break in data and also because the current information contributed importantly to the range-watershed study.

Work for the Coming Year

The principal effort during 1943 will be on the range-watershed condition studies which it is expected will yield data that may serve as a guide for determining the trends in condition on high summer range lands. A report of findings will attempt to develop criteria particularly with reference to soil movement and stability. Climatic records will be taken and ecological observations will be prosecuted in only enough detail to maintain long-time records and to support the principal studies. Several short manuscripts will also be prepared on various phases of the work as it progresses.

SAGEBRUSH-WHEATGRASS RANGES

Grazing experiments conducted at the U. S. Sheep Experiment Station near Dubois, Idaho have gone through one rotation cycle. Data from this phase of the pasture studies are being analyzed and the results will be published as a guide to the management of the spring-fall ranges of this region. The pastures are being grazed in such a manner as to make possible the continuation of the pasture studies after the war with a minimum of loss due to the present cessation. Very few plant data are being taken.

The major effort on this project is directed toward preparation of a bulletin dealing with sagebrush burning as a means of increasing forage on the spring-fall ranges. Such phenological and weather observations as are necessary to prevent a break in long-time records, together with analysis of certain grazing data, were made by a field assistant.

Sagebrush burning under certain conditions and executed in the proper manner affords a promising opportunity to increase forage on spring ranges and therefore the production of meat and wool. A summary of the results of the burning study is given below.

Forage Production on Sagebrush Range Markedly Increased by Burning

Many range fires in the past have done irreparable damage to the forage and soils and they still constitute a great menace to the livestock industry. However, research and experience have shown that under certain conditions of topography, soil, and plant cover, fire may be safely and effectively used in removing sagebrush and in so doing greatly increase range forage. On the experimental tracts this increase amounted in 3 years to as much as 80 percent.

Burning is recommended as a means of increasing meat and wool production so much needed by our nation at war. But such a program must be rigidly guided by the facts and principles that will eliminate the danger from fire and assure increased forage production.

The burning experiments were conducted on range lands near St. Anthony in Fremont County, Idaho and at the U. S. Sheep Experiment Station.

Planned burns were studied in detail by laying out a series of plots permanently marked with iron pegs. Vegetation inventories were taken on plots near the pegs before burning, one year after burning, and again about 3 or 4 years later. Each of the three areas were lava-plain sagebrush-grass range of gentle slope having good soil between the broken jagged pieces of lava rock. In all three cases, grass under the sagebrush was abundant enough to revegetate naturally when the sagebrush was removed by fire. On each area also, grazing was not allowed the first

year after the fire, and only such grazing as was estimated to be proper during the second and later years. The study in Fremont County and the first of two at the U. S. Sheep Station were very carefully designed to obviate difficulties frequently encountered. A suitable area was selected and marked at mechanical intervals with 400 iron pegs. A forage inventory was taken in plots located at the pegs. Plots in strips that escaped the fire were used to furnish data from unburned range.

On three other areas the sagebrush was burned off by accidental fires. They were all in the general vicinity of the Sheep Station on gently sloping lava-plain range roughly similar to the areas on which planned burning experiments were conducted. One of the areas had a reasonably good understory of perennial grass, one a poor understory, and the third, being on previously cultivated land, practically no grass at all. Since no control of grazing was exercised, animals congregated the first year after the fire and grazed off the fresh feed closely. Grazing was also unrestricted in succeeding years.

In all six cases, the amount of vegetation and its total forage value on burned range was compared with the amount of nearby unburned range that was similar except for the burning. On the three experimental burns opportunity was afforded to study the effects of the fire on individual forage species one year after the fire and at later periods. Effects of the fire on the soil was tested by drawing soil samples from 0-1-inch and 1-6-inch depths. Soil samples were also taken from a number of additional burns, comparing in each case the nitrogen, the moisture-holding capacity, and the pH value of soil from burned range with that from nearby range that was unburned. An effort was also made to describe the conditions under which sagebrush burning would likely give good results.

Before being permitted to burn a range, a stockman should be sure that the proposed area will give good results from burning. He should also make adequate preparations to control the fire and so conduct the actual burning as not to endanger other range lands or ranch property. It is recommended that some responsible public agency be empowered to make the inspections required to assure that these purposes are achieved.

Findings of the Investigation

Several rather specific findings came from the investigation, which taken together led to the general conclusion that burning properly used can be a beneficial tool in increasing forage production. In the beginning, it was rather unexpected that the findings should point so uniformly to beneficial results from burning conducted under controlled conditions. The principal findings are summarized in the following paragraphs.

1. Big sagebrush (Artemisia tridentata) is practically eliminated by burning. Plants burned and even those merely well scorched die and do not sprout again from the roots or crowns. Sagebrush reoccupies the area only when a new crop of seedlings are propagated. Burning off sagebrush removes a considerable obstacle to good sheep management and makes the feed more available.

2. Under controlled burning, or "prescribed" burning as we might say, the production of perennial grasses was nearly doubled; the production of broadleaved herbs increased slightly in one case and nearly doubled in another, the third being intermediate. Bitterbrush, the one really palatable shrub occurring in quantity on the three areas, had the top growth completely killed but about 20 to 25 percent of the plants sprouted from below ground. On two areas it had returned to about one-third its preburn production and on the other to only one-sixteenth. Young bitter brush plants however were abundant, assuring a good stand in a few more years.

3. Though grasses and weeds as a whole increased rapidly and remarkably in production, different species responded differently. Rootstock plants showed no sign of injury and began to increase at once, whereas many bunch-forming plants suffered some injury. Thickspike wheatgrass considerably more than doubled its production. Other valuable forage species showing no delay in growth response, that is, suffering not even a temporary set-back were crested wheatgrass, Douglas sedge, arrowleaf balsamroot, commandra, fleabane, velvet lupine, Stansbury phlox, and downy rabbitbrush.

4. The following valuable forage species were injured in only a slight degree, and after a year or so overcame the unfavorable effects of the fire: bluebunch wheatgrass, junegrass, Indian ricegrass, Sandberg and Nevada bluegrasses, needlegrasses, painted cup, tapertip hawksbeard, tailcup lupine, and royal penstemon.

5. A few good forage species were severely injured by fire and did not fully recover before the last observations were made 5 or more years later (1942). The injured species are: bluebunch fescue, threadleaf sedge, wyeth eriogonum, hoary phlox, and bitterbrush. It is considered risky to burn off a range on which bluebunch fescue predominates as it might be greatly injured.

6. Under planned burning forage amounting to 38 sheep days grazing capacity per acre was produced in 1940 on the range burned in 1933 as compared with 21 sheep days on adjacent unburned range. For the 1936 burn the figures were 34 sheep days as against 19, and for the 1939 burn 61 as against 40. These amounted to gains in forage value of 83, 79, and 52 percent, respectively, for burning. Increased availability of the forage on the burned range was of great importance in each case.

7. On three tracts burned without plan and thereafter grazed without control, grasses, herbs, and shrubs all decreased as a result of burning and subsequent grazing. Even with the greater availability of forage that resulted from the removal of the sagebrush, these areas either lost in grazing capacity or gained only slightly.

8. Soils on the planned burns showed no injury from the fire, whereas on the unrestricted burns, the soils had in 3 to 5 years after the burn decreased considerably in both nitrogen and moisture-holding capacity. These losses are undoubtedly the result of soil erosion. Burning had no effect on the pH values.

9. The details of the investigation as well as the data indicate that sagebrush fires themselves do little injury to perennial forages except on a few species, but that unrestricted grazing immediately thereafter permits the overuse of forage plants before they can revegetate. This both weakens the plant and encourages active soil erosion, neither of which occurs except in a minor way on range where grazing is managed after the burning.

10. On all three ranges that were burned without plan, sagebrush had reoccupied the areas. Instead of 36, 35, and 40 mature bushes per 100 square feet before the burning there were 58, 97, and 147 young bushes, more than double as many. Since these bushes were not suppressed by grasses and were growing vigorously it is only a matter of 3 or 4 years until the small plants grow up, at which time there will be a much denser stand of sagebrush than before the fire. On the other hand, there are on the average only 4.5, 3.3, and 2.0 young bushes per 100 square feet on the three ranges burned according to plan. The abundant grass growth has so greatly suppressed the young bushes that sagebrush is making little or no headway toward reoccupation of the areas. Considerable acreages have practically no sagebrush on them.

11. All observations and data point toward a good cover of grasses and herbs being able to prevent an early development of a new thick cover of sagebrush.

12. With well organized burning in 1,000-acre blocks, sagebrush ranges can be burned and protected against escape of fire for 20 to 30 cents an acre.

13. Inspection as to suitability of an area for burning and preparations for control of the fire should be made by competent men and the burning done under satisfactory supervision and legal permit.

14. Assurance should be required that the grazing which comes after burning will be properly restricted.

Work for the Coming Year

The Farmers' bulletin on sagebrush burning begun in 1942 will be completed early in 1943. The preparation of another manuscript dealing with management of spring-fall ranges in Idaho will be pushed as rapidly as possible. The pastures will be grazed to maintain the effect of long-time treatment but vegetation studies will be conducted only on a minimum basis. Observations on burned-off areas will be continued as opportunity occurs but without detailed study.

GRAZING MANAGEMENT OF WINTER RANGES

Grazing experiments being conducted at the Desert Branch Experiment Station have been in progress for 5 years and have yielded valuable data directly applicable to the management of the great area of winter range in the Intermountain Region. These data are being compiled, analyzed, and formulated into a manuscript which when published will be a guide of valuable facts and principles for the managers of the range and the operators of livestock in their production programs. The pasture experiments are being continued because of their direct applicability to war production and in order not to lose the continuity of the grazing studies, but all other data-collecting activities have been eliminated.

Good Grazing Practices at Desert Experimental Range Increase Forage and Livestock Production

Grazing investigations at the Desert Experimental Range, now at the end of the first 5-year period, have yielded important and clear-cut findings regarding the effect of intensity of grazing on forage and sheep production. Though not yet complete, the studies establish that good management during grazing both as regards degree of forage utilization and the manner of handling the sheep builds up vigor in the forage plants, increases their reproduction and yield, improves the quality of the forage, sustains an upward trend in range conditions and reduces soil losses. As a result of these beneficial effects on the forage and soil, the sheep using that range respond in greater wool and lamb production, in greater body weight and lower death losses, and in smaller requirements for supplemental feed. The operators also received a decidedly higher net income.

The term "moderate" grazing in these experiments is applied to an intensity of use, which at the end of the grazing period left on the ground 20 to 30 percent of the forage produced by such high-value species as Indian ricegrass, black sage, and winterfat. Species of lower palatability were naturally grazed somewhat more lightly. "Heavy" grazing removed most of the current growth of the three high-value species named and more of the low-value species than was taken under moderate grazing. "Severe" grazing was somewhat heavier than "heavy" grazing. Use on most of the winter ranges of the Intermountain Region is from heavy to severe, except in a few tracts rather distant from watering places where it is from moderate to heavy.

The data underlying these findings were obtained from three sources: (1) from 18 fenced pastures grazed under control at light, moderate, and heavy intensities of use at different periods of the winter season; (2) from four allotments on the Desert Experimental Range on which whole herds of sheep are grazed under the herder at moderate intensity in a manner that makes use of open herding and other good practices; and (3) from ranges adjacent to the experimental range on which herds graze according to usual practices and utilize the forage rather heavily. Data are especially reliable as this is a well-designed experiment with replicated treatments assigned at random to the pastures. The four herded allotments replicate on a large scale the most effective grazing treatments.

The pastures and one of the herd allotments on the experimental range were grazed by herd "A" whose owner is a brother to the owner of herd "B" which grazed on heavily used range near the experimental area. In alternate years herd "B" grazed on the experimental tract and pastures and herd "A" grazed on the range used the previous year by herd "B." This exchange of range is repeated each year. The sheep in these two herds were derived from a herd previously operated by the father of the two brothers. As the handling and breeding have been similar since dividing the sheep, the two herds resemble each other as much as could be expected. The data derived from the studies are therefore primarily the result of grazing treatments. Comparisons were also made between the herds grazing on the experimental range and those grazing in the vicinity on heavily used range.

Increased Yields and Improved Quality of Forage

Moderate grazing combined with more uniform distribution of the animals, better seasonal use, and more adequate herd management over a period of 4 years, from 1934 to 1937 inclusive, brought about a decided increase in plant vigor. As measured in forage production per plant, the yields on moderately grazed ranges were 1.5 to 4.8 times as great as those on heavily used range. These measurements were made on Indian ricegrass, black sage, and winterfat. Establishment of young plants was invariably greater on moderately used range even though as great or greater germination had in many cases occurred on heavily used range. Young plants were in most cases killed by tramping or by being pulled up under heavy grazing use. As a result of increased plant vigor and greater establishment of young plants, the total perennial forage yields, including both high- and low-value forages, increased from two to seven times with an average of more than three times.

Quality of the forage also increased appreciably, largely by the near elimination of Russianthistle on ranges that were grazed moderately. As an average Russianthistle constituted from 30 to 50 percent of the forage on heavily used ranges and up to 80 percent on severely used ones. Under moderate use or full protection for 3 to 5 years, the perennial species regained vigor and crowded out all except traces of Russianthistle which on good range usually amounted to less than 1 percent of the forage yield. In most of the cases high-value forage such as Indian ricegrass and winterfat increased most noticeably, thereby greatly improving the quality of the forage.

Of major interest also was the fact that increase in forage yield and the degree to which Russianthistle was crowded out were just as marked on ranges that were moderately grazed as on similar adjacent range that received no grazing at all by virtue of being fenced tight. It is a necessary conclusion from these data that under these winter range conditions, perennial range forages that are greatly weakened by heavy to severe grazing will recuperate about as rapidly and as fully under moderate grazing as under no use at all. Complete removal of livestock on such ranges is therefore an unnecessary form of range protection, except for special purposes or on special areas.

Besides being a low-quality forage, Russianthistle was found even on heavily used ranges where it is most favored, to be extremely variable so far as amount of forage produced is concerned. On two parts of the range where the greatest volume of thistle is produced year after year, variations in season reduced the yield in 1938 to 2.4 percent in one case and 3.7 percent in the other of what was produced in 1936. The yield in 1939 and 1941 were again high but it was almost zero in 1940 and 1942. Yields of perennial forage in 1938 were fully normal, that is, 100 percent of average and those of 1940 under moderate grazing were 72 percent. Even if Russianthistle were a high-quality forage, its extremely erratic yield in dry, cold seasons makes it highly hazardous as a major source of forage. It is, of course, "better than nothing" as some stockmen say, but good management is so effective in restoring high-quality forage species that effort should be channeled to that end, thereby largely eliminating Russianthistle and doing away with the problem it presents.

Nor are the increases cited all of the story. The ranges on which this notable betterment has occurred are still continuing to improve. Good grazing practice has supported an upward trend in forage yield that still goes on. It improved more rapidly during the first 3 or 4 years, but the data show that it is still increasing. The potential yield of moderately grazed ranges is also being set higher as time goes on, because the soil is being more fully established. This is made clear by the reduced movement of soil by both wind and water. The better the soil the more forage it <u>can</u> produce--and in time, <u>will</u> produce.

Livestock Production Also Increased

Livestock production has naturally increased as forage quality and yield have improved. Wool yields, lamb crops, and body weights of ewes on moderately used ranges are all significantly higher than on heavily or severely grazed ranges. Death losses are lower and the amount of supplemental feeds used is smaller for the sheep on moderately used range. The ample feed on moderately used range also reducesother expenses and permits better management practices. Increased production combined with lower expenses inevitably brought the operator greater net incomes.

Ewes on range moderately grazed since 1933, though heavily grazed before that time, produced wool yields which as a 5-year average (1937-1941), was approximately 1 pound heavier than for similar sheep similarly handled on heavily used range. It was also found that ewes 2, 3, 4, and 5 years old produced more wool than yearlings or than older sheep. Ewes 10 years old produced only 85 percent as much as ewes 2 to 5 years old, and yearlings about 70 percent as much. Incidentally it was found that yearlings that were low wool producers nearly all continued to be low producers as long as the record continued--in this case 5 or 6 years. On the other hand, sheep which as yearlings were high wool producers in most cases continued to be good producers thereafter. This strongly suggests an active program of culling out low wool producers.

Lamb crops on the average were 3 to 5 percent higher in the herds kept on moderately used range than in those kept on heavily used range.

In body weight all ewes lost weight from the time they came to the desert, about November 1, until the next spring. As a 5-year average some 600 to 800 tagged ewes showed that those on moderately grazed range for from 70 to 103 days lost 8.4 pounds less body weight than those on heavily grazed range for the same period.

Death losses of mature ewes as a result of malnutrition were almost wholly prevented by the more ample feed available under continuous moderate grazing. During 6 years (1936-1941) the total losses on winter range were 2 to 5 percent lower for sheep on moderately grazed range.

No supplemental feeding has been required in the 7 years (1935-1941) during which sheep have been kept on moderately grazed range. Other sheep operators have fed during periods of feed scarcity from a few days to several weeks in 3 of the 7 years 1/5 to 1/2 pound of corn or cottonseed cake per day as an emergency ration, costing nearly $100 to more than $400 per band on heavily used range.

Availability of moderately used ranges greatly reduced the management difficulties encountered on heavily grazed range such as trailing to feed, restlessness of poorly nourished animals, the delaying effect of moving weak animals, and hauling and feeding those that became too weak to keep up with the normal movements of the band.

Higher returns combined with the lower expenses incurred by the sheep on moderately used range gave markedly greater income than from those on heavily grazed ranges. The size of the increase in income varied from year to year with expenses and prices for lambs and wool. For the winter of 1936-37 it was $1,200 greater for a winter band of 2,500 ewes.

Work for the Coming Year

Completion of the manuscript begun during 1942 will be given first priority until it is completed. The pasture and grazing allotment treatments are directed toward increasing our information concerning meat and wool production. Because of this and because they are not yet completed, they are to be continued during 1943. Weather and ecological studies necessary to maintain long-time records and which contribute to pasture-treatment study are to be continued on a minimum basis. Preparation of findings for publication will be stressed.

ARTIFICIAL REVEGETATION

It was not difficult to gear the artificial reseeding work to an all out war effort. Results of investigations carried on during the past years are proving invaluable in motivating and guiding widespread reseeding of deteriorated range lands in the Intermountain Region. Efforts during the past year of our reseeding staff have been directed primarily toward making information available to interested agencies and ranchers and to giving advice and guidance to reseeding programs on the national forests and private range lands and in stabilizing the soils of the Ogden military arsenal by revegetation.

Our reseeding efforts were well distributed over the entire region. Hull worked in Idaho, Robertson in Nevada, Plummer in central and southern Utah, and Hurd helped plan and execute the work at the Ogden arsenal.

During these winter months revegetation data have been tabulated and manuscripts will be prepared which will present the findings and conclusions from our studies and experience.

Research Points Way for Action Program on Large-Scale Reseeding

The Artificial Revegetation Project of the Intermountain Forest and Range Experiment Station has demonstrated that artificial seeding of range areas, which have been so abused as to retain only a small fraction of their original forage plants, is not only possible but practical. A fundamental program of research has provided a number of basic facts concerning how, when, where, and what to reseed upon which a practical range reseeding program has been based.

Of importance also is the part the station has played in interesting range administrators and range users in reseeding and dispelling the skepticism which had prevailed concerning its value. Early reseeding was conducted in a haphazard trial and error manner. Practically no research had been conducted and, since the basic relationships underlying success or failure in planting had not been provided, widespread failures resulted. Disappointment and discouragement followed, and when an adequate research program was finally inaugurated many range men were apathetic concerning the promise of range reseeding. However, research findings have pointed the way to practical successful plantings, and interest has again been aroused. As a result of demonstration plantings, and making known the results and benefits of the large-scale plantings that have been made, range administrators, federal, state, and private, have embarked on an ever-expanding range reseeding program. Although thousands of acres have already been seeded, this represents only a beginning.

Among the outstanding specific contributions of the Artificial Revegetation Project are the following:

1. Exhaustive search and widespread plot tests involving over 350 species have indicated which species are valuable for each of the reseeding problem types. Species that are now actually in use in practical scale reseeding operations are:

   a. Depleted sage, burned sage, and abandoned cultivated lands; Agropyron cristatum, A. spicatum, A. inerme, A. trachycaulum, A. smithii, Arrhenatherum elatius, Oryzopsis hymenoides, Poa bulbosa, winter rye.

   b. Depleted mountain brush, aspen, and subalpine areas; Agropyron trachycaulum, A. subsecundum, Bromus carinatus, B. inermis, Dactylis glomerata, Elymus canadensis, E. glaucus, Poa ampla, P. pratensis, Phleum pratense, Melilotus officinalis.

   Many other species have been found to be worthy of more extensive trials, but adequate seed supply is not available.

2. In regions with good fall precipitation, early fall planting generally gives best results. If fall rains cannot be depended upon, planting should be done in late fall, although in areas subject to frost heaving and winter killing, spring planting is preferred. Furthermore, some important species which can be successfully established only by spring planting have recently been recognized.

3. Seed should be planted at a depth roughly proportional to the size of the seed and broadcasting without covering is almost certain to result in failure. Several efficient implements have been devised to plant seed in accordance with this requirement.

4. Plant competition has been recognized as an important factor in artificial reseeding. Stands of big sagebrush, tarweed, cheatgrass brome, or other weedy species which completely dominate the site prevent establishment or greatly suppress development of reseeded species. Successful reseeding projects take this important relationship into account. Research has thus provided the key for basically sound reseeding. Many other research results involving the grazing value of species in pure stand and in mixture, the management of reseeded stands, development of improved strains of proved species, and more efficient and economical methods of seeding under difficult conditions are rapidly being realized from active studies.

5. Widely scattered plantings, together with critical evaluation of climatic and edaphic conditions have provided a basis for judicial selection of sites for reseeding and for prescribing the most desirable methods and species to use on each.

6. A survey of some of the economic aspects of range reseeding in the valley foothill zone has indicated that the total cost of planting can be expected to be equaled by the increased value of forage alone in from 7 to 10 years after planting, depending upon the site.

Based on these findings and following the detailed suggestions as well as the general leadership of the project the expanded reseeding program has taken shape. In recognition of the value and promise of range reseeding as indicated by our research and demonstration plantings a considerable acreage in the Intermountain Region has been treated to date. Region 4 of the Forest Service has seeded nearly 22,000 acres, most of it in the past 2 years. In 1940 and 1941, 161,000 acres had been seeded by ranchers under the Utah AAA program. Other agencies have seeded additional thousands of acres.

As a direct contribution to the war effort the Artificial Revegetation Project has contributed directly to the seeding for dust control, reduction of fire hazard, and as an aid to concealment on many critical areas on Army establishments in the arid West. At the 3,000-acre Ogden Ordnance Depot, for example, a comprehensive reseeding program was developed and supervised by station technicians. Various types of planting as required according to local conditions and covering 713 acres have practically eliminated the serious wind erosion problem on the area seeded. The station is also supplying the leadership for the preparation of a concise, authoritative guide at the request of the Army to facilitate effective planting of military areas in the West.

The effect of this program in terms of more and better range forage is already becoming evident. Reseeding of depleted range lands has resulted in increases of from two to sevenfold in annual grazing capacity. On the basis of available measurements, it might be concluded that when a fully productive, mature stand is attained on the 22,000 acres so far reseeded by Region 4, the grazing capacity will be increased by more than 16,000 animal-unit months annually. This plentiful forage, where little grew before, looms large in view of the general scarcity of feed on the spring-fall ranges in the Region.

Continued prosecution and expansion of range reseeding is certain. The value of the method in alleviating the balance between grazing pressure and limited range forage has been proved and is being more convincingly demonstrated as additional reseeded areas come into full production. Region 4 has recommended reseeding of national forest areas totaling over 370,000 acres. On some of these areas, suitable methods of planting have yet to be developed; on many of them actual seeding can be initiated as rapidly as funds and facilities permit. It is important that research maintain a position of leadership in the field in order that the program, as it develops, will be kept on a sound basis and mistakes and disappointments will be avoided.

It is appropriate to ask how far we can expect to go in the range reseeding program. The more favorable areas are, wisely enough, being seeded first and as we progress to the more difficult sites, the problems must be expected to become more troublesome and success less likely. But only a beginning has been made, and the end is not yet in sight.

Work for the Coming Year

Treatises on "How to Reseed" in each of three states--Idaho, Nevada, and Utah--will be prepared, mimeographed, and distributed to aid in the fall reseeding program. In addition guidance will be available to various public agencies and private stockmen and others who wish help in reseeding work. In the field guidance and information on large-scale plantings will be stressed with special emphasis on the three problems most in need of immediate solution, as follows:

1. Depleted openings in the aspen zone now dominated by tarweed, knotweed, and other low-value annuals. These sites, many of them naturally productive, represent a considerable area on national forest land but as yet successful methods of planting them are only being tried.

2. Extensive depleted sagebrush areas are producing only a small part of the forage of which they are capable. Studies are needed to place the work on a sound basis and to devise more economical methods of removing the sagebrush, or planting among the bushes.

3. Cheatgrass brome dominates thousands of acres of land in the important spring-fall range belt. Replacement of this unstable, low-value species by palatable perennials is a most urgent necessity for increased livestock production, but the problem is difficult and many reseeding attempts have fallen short of success. A thorough study applied to this problem is needed.

UTILIZATION STANDARDS STUDIES

This project has yielded data extensively used by the Agricultural Adjustment Agency in the prosecution of their range livestock program. In addition to furnishing volume-height data for several species, and written reports, Clark has participated in the AAA range training program and has furnished advice and guidance to state and county range examiners and state and county committeemen for Utah, Idaho, and Nevada.

A manuscript that presents the results of volume-height studies which will be of value to the Forest Service, AAA, and other range administrators, is nearly completed and soon will be submitted to the Journal of Forestry for publication. Another manuscript presenting available information and data of immediate use to stockmen is being prepared. This will set forth the results of studies regarding resistance of plants to grazing, what constitutes proper range use, and means for judging range conditions for major range forage types of the Intermountain Region. Only enough field work on the old but valuable studies was done to maintain the continuity of essential studies and records.

Some of the findings of volume-height relationships of range forage plants are presented in the following paragraphs:

Volume-Height Relationships in Range Plants

Studies on volume-height relationships of several range forage species have been carried through a 4-year period on summer range lands in central Utah. To facilitate field use these relationships have been presented in a scale form which can be directly read for any height of stubble remaining. Comparative tests made by the volume-height method and the direct ocular estimate method have demonstrated that the volume-height method is (1) no more accurate, (2) not as adaptable, (3) more time-consuming, and (4) more complicated in field and procedure than the ocular estimate method.

Because volume-height scales involve a measurement procedure there has been a tendency to accept the accuracy of the method without question. A factual basis for this acceptance has not been established under actual field conditions.

At the outset it should be stated that although volume-height scales are already rather widely used they are applicable only to grasses. They are wholly inadequate for measuring degree of use on browse or "weeds"--i.e. species having an indeterminate type of growth. Limited thus to grasses other methods must be resorted to on ranges supporting largely "weeds" and browse species when an appraisal of use is desired.

When limited to local type, for which volume-height scales are known to be representative, the volume-height method and ocular estimates are essentially comparable with respect to the accuracy they give. This holds whether the methods are compared on a plot or on an individual plant basis provided an adequate sample is taken. In field determinations on individual plants the volume-height method took approximately 3 to 5 times as long as the direct ocular estimate method. On a plot basis the differences may become greater, since size of plot, density of stand, and number of plants are variables which either singly or in combination can disproportionately multiply the amount of work involved in the volume-height method. Reid and Pickford working with bunchgrasses on summer range in Oregon found that the volume-height method entailed measuring an average of 10 plants per plot to obtain the comparable value obtained by a single estimate by the ocular method. Carried to the ultimate, the volume-height method in dense stands can be almost as tedious and laborious as mapping vegetation. Where time is the limiting factor, as usually is the case in utilization inspections, the accuracy of the two methods is no longer comparable since the use of ocular estimates permits a greater area to be observed and many more appraisals of degree of use to be made.

There are other features of volume-height relationships which are of major importance in the application of the volume-height method to general field use. The volume scale derived from a sample or an aggregation of samples is based on a fixed pattern of volume distribution. In order to be widely applicable to general field use rather than to local types or specific samples, this distribution pattern or growth form for a given species must be relatively static for that species, a condition which does not exist because of almost limitless number of growing conditions arising from seasonal, soil, and elevational differences. The only purpose charts or gages serve is to align variable height values against a fixed volume distribution. The only possible adjustments are strictly linear.

Examination of samples collected at different elevational zones from different sites within zones and in different years clearly shows that a given species does not have a constant or definite growth form. This lack of constancy is the rule, not the exception; it occurred in all species observed. It is axiomatic that grasses growing in dense stands on favorable sites grow tall with relatively scant basal leaf growth and plants growing in open stands have low stature and greater basal growth. The amount of material removed when 4 inches of stubble was left on slender wheatgrass plants from the oakbrush and spruce-fir zones showed an average yearly difference of approximately 10 percent. The variation in volume relationships between years was even more extreme, differences in volume at this same level amounting to 24, 9, and 16 percent respectively for the oakbrush, aspen, and spruce-fir zones. Grazed to the same stubble heights the volume removed from mountain brome plants varied by 19 percent between zones in one year and 17 percent for a given zone between years. Corresponding variations in smooth brome was 14 and 15 percent for between-zone and between-year comparisons. Letterman needlegrass at 3-inch level

fluctuated 13 percent for zone and 20 percent for year differences. At the low level of only 2 inches of stubble, Kentucky bluegrass showed differences of 25 percent in volume between zones in a given year and 33 percent between years for the same zone.

Differences in volume relationships of the magnitude just noted at these low stubble heights introduces a major problem in adapting volume scales to field use. It precludes the possibility of using an "over all" scale or scales prepared for regional areas or specific years on local range types with any assurance that degree of utilization can accurately be determined.

If volume is plotted against percentage height instead of against actual height the full variation in growth form is fully shown since height then ceases to be a variable. When this is done it is noted that slender wheatgrass is the only species studied which exhibited any marked degree of constancy of growth form. With this species the variation as noted above was reduced by approximately one-half. For the other species no decrease in variation resulted from this sort of alignment of the two variables; for some species the differences actually are greater.

Errors in making stubble height determinations in the field, even if compensating for height, result in cumulative errors in final utilization values read from a volume scale. If personal error or bias is introduced in measurements then errors in final utilization readings become even more biased and unreliable. This results from the very nature of volume distribution which tends to be strongly conical rather than cylindrical. The difficulties encountered in determining stubble height may be fully as great as in making utilization estimates directly. Only when a plant is cropped evenly can stubble height be accurately measured. Under an uneven pattern of herbage removal stubble height becomes a highly conjectural value, and is fully as much the product of judgment as direct utilization estimates. It is suggested that one can correct for this by taking two or more measurements on each plant. In doing this one is dealing with subsamples which are not comparable to the sample from which the original scales were prepared--the subsamples being only corners of plant clumps which resembles neither the whole plant nor the original sample in growth form.

This variation in volume-height relationships does not preclude the possibility of preparing scales for specific areas which will accurately interpret degree of use for any one year. If the preparation of the scales and their use is restricted to a specific site and year, one is dealing with samples from a given population, and within the limits of sampling error one can expect to draw comparable samples from that population. If, however, one attempts to use a scale prepared from such a population on another area having a different population then the scale will not fit. If this procedure is followed accurate results can neither be obtained nor expected regardless of intensity of sampling. Compromise values, which in two or more independent determinations may show close agreement, will be secured; that is, agreement between two biased measurements and not accuracy will have been attained.

A great deal of the variation noted in volume-height relationships for plants growing at different elevational zones and plants for different years is attributable to population differences. Marked inequalities in height and weight of plants are evident in several of the samples. However, in addition to these direct differences there are interactions of height on weight. This is borne out by the fact that neither plants of a given height class nor plants of a given weight have comparable volume distribution patterns in different years and zones. For example, a difference of 15 percent in volume removed at 4-inch stubble height was noted for Letterman needlegrass plants 13 to 16 inches tall (which is near the medium class) for the years 1938 and 1939.

An examination of some plant vigor data demonstrates some of the contrast in plant populations encountered in making utilization determinations under field conditions. In actual practice much greater extremes than these are met with, but these serve adequately to demonstrate the problems involved.

An enclosure was established on a site considered to be in good condition with respect to density, soil conditions, general vigor, and constituents of the plant society. The area was protected through two seasons. Prior to fencing, the whole site had been moderately used in late summer and fall. During the two years of protection the adjacent area was utilized to approximately 60 percent for slender wheatgrass and mountain brome. Just prior to grazing in midsummer of the third year, 400 plants each of mountain brome and slender wheatgrass were cut along transect lines within the former enclosure and a similar number of transect lines laid out approximately 10 feet beyond the old fence line. The plants were weighed and measured individually. The following tabulation summarizes a portion of these data.

Variation in weight of plants at selected heights and in height and weight of plants in entire sample for plants growing on same site, some grazed moderately, and some protected for two years.

Species and Treatment	Weight of Plants (Grams)					
	At Selected Heights				Entire Sample	
	15"	20"	25"	30"	Av. Height (ins.)	Av. Weight
Mountain brome						
Protected	5.80	10.20	17.85		23.7	9.99
Grazed	4.25	7.55	13.35		22.9	6.00
Difference	1.65	2.65	4.50		0.8	3.88
% of grazed	38.8	35.1	23.7		3.5	63.5
Slender wheatgrass						
Protected	3.75	5.82	8.55	13.70	19.6	11.98
Grazed	2.75	4.48	6.85	11.35	17.9	7.09
Difference	1.00	1.34	1.70	2.35	1.7	4.89
% of grazed	36.4	29.9	24.8	20.7	9.5	60.0

It can be seen that volume-height relationships are not constant for plants of same height, nor for the two plant populations. The protected site had 60 percent more brome plants that attained a height of 70 cm. (27.6 in.) than did the grazed area, and 79 percent more wheatgrass plants that reached a height of 60 cm. (23.6 in.) than the grazed site. Conversely, there was 25 percent more brome and 63 percent more wheatgrass plants below 30 cm. (11.8 in.) on the grazed site than on the protected. These differences in plant sizes and plant populations are so great that no scale for universal use could possibly measure percentage utilization for both sites accurately except where the degree of use approaches 100 percent, in which case nearly all of the population differences are obliterated. Only by preparing separate scales for each site could use on these two areas be determined with any acceptable degree of accuracy.

The question might logically be asked, can utilization of such variable plant populations as just noted be ascertained by the ocular estimate method? Since comparative tests were not made in this case, results cannot be cited. In the judgment of men trained in ocular estimate methods degree of use can be rather accurately determined. In training one learns to evaluate growth characteristics and can mentally appraise differences in plant vigor and other characteristics of growth such as leafiness, compactness of stand or clump, height, and in addition assess the relative weight effects of any nonuniform pattern of utilization. It has been shown that with trained men degree of use for complex plant types can be determined with acceptable accuracy by the ocular estimates on plots. Why should we then advocate a slower, less flexible method, and one no more accurate?

SPRING GRAZING OF WILD-HAY MEADOWS

To provide more spring forage and at the same time relieve overstocked ranges some ranchers are extending the grazing period on their meadow lands from which hay is harvested. The advisability of such a practice has been questioned by some stockmen because of a belief that late grazing adversely affects amount of hay produced. Knowing that more general use of hay meadows would relieve pressure on open ranges a demonstration and study was set up on the ranch of James Jensen of Big Piney, Wyoming in 1936, designed to give an approximate answer to this question. The discussion and conclusions recorded below are the results of observations and data recorded over a 7-year period.

Effect of Spring Grazing on Yield and Quality of Forage Produced on Wild-Hay Meadows

That wild-hay meadows can be grazed for a period of 30 to 40 days during the spring without decreasing the yield or quality of hay produced promises to contribute importantly to increased production of meat, wool, and hides--major objectives in the nation's agricultural production goals--and in addition relieve the grazing pressure on overgrazed spring ranges. This was demonstrated in a study conducted over a 7-year period on typical wild-hay meadow lands near Big Piney, Wyoming. The study included three periods of spring grazing set up to give a short, medium, and long spring grazing period before allowing the forage to grow into hay.

Findings show that both quality and tonnage of hay are fully as good or somewhat better from meadows grazed for a period of 38 days in spring as from meadows grazed only 15 days. An additional 14 days of heavy grazing, or a total of 52 days, resulted in slight reductions in hay yields. The highest total forage yields (hay plus pasturage), however, was secured from the meadows subjected to the long period of spring grazing, with the medium period second, and the short period lowest. Quality of hay, evaluated by observable characteristics of the hay and by determining the crude protein content, was highest in every year for the meadow grazed the longest. Botanical surveys of the various meadow units together with reversal of grazing seasons between the short and long period units in the first and last years of the test fail to show any cumulative effects from the different treatments.

The meadows under observation are thought to be rather representative of wild-hay meadows in the Intermountain Region. The three units were remarkably uniform with respect to soil drainage, productivity, and vegetation. The plant cover approximates the following average: mixed grasses 14 percent, mixed sedges 47 percent, spike rush 11 percent, Baltic rush 24 percent, and broadleaf herbs 4 percent. The variation in weather and other seasonal conditions encountered during this study, including both drought years with scant water supply and favorable years with ample irrigation water, offers a good cross section of the local climate.

With minor exceptions all units were pastured continuously from date winter feeding was discontinued until their respective closing dates. During the 7 years an average of 15, 38, and 52 days of spring grazing use was secured from units pastured for short, medium, and long periods, respectively--a total difference of 37 days in period of use. Beginning and end dates of grazing seasons fluctuated, as also did the rate of stocking in the various units over the period to meet yearly differences in forage production and operational conveniences. Closing dates were May 3 for the short grazing period, May 26 for the medium, and June 9 for the long grazing period. The rate of stocking in the meadow grazed for the long period was at a somewhat higher rate in approximately the last third of the grazing season than in the earlier part, and was also at a higher rate than the units grazed for short and medium periods. Over the 7 years, grazing use per acre averaged 10.8 animal-unit days for the meadow grazed for a short period, 15.4 days for medium period, and 38.7 days for the meadows grazed for the long period each spring.

Except for drought years, hay yields under each of the different treatments have continued fairly uniform. Average hay yields were 1.66, 1.67, and 1.46 tons per acre respectively, for the meadows grazed for short, medium, and long periods. Reduction in the yield of hay following the long period of spring grazing results both from extreme length of grazing season and greater intensity of grazing. For example, in 1937 the long season unit grazed from April 22 to May 20 at a moderate rate was pastured for a 22-day period, May 21 to June 11, with 105 head of heifers, and furnished 71.3 animal-unit days of pasturage per acre--47.5 animal-unit days more than the unit grazed for the short period. Hay yields amounted to 1.85 and 1.49 tons per acre respectively for the units grazed for short and long periods. In the drought year of 1940 the long season unit pastured only to May 20 provided 39.1 animal-unit days more use than the short season unit with a difference in hay production of only 0.08 ton. During the period of study the long season unit has furnished an average of 27.9 animal-unit days more pasturage than the short season unit and 23.3 more days than the medium season unit, with a reduction in hay yields of approximately 0.20 ton per acre over these other meadows.

Total forage yields were approximated by converting pasturage through standards methods to an equivalent amount of hay and adding these values to hay yields. Then this conversion is made the pasturage consumed amounted to the equivalent of 0.13, 0.22, and 0.47 ton per acre for the short season, medium season, and long season grazing. Total yields thus become the equivalent of 1.79, 1.89, and 1.93 tons of stack cured feed per acre for the short, medium, and long season units, respectively. The differences noted were consistent, being higher under long period grazing use than under short grazing period in all years, and higher than under medium period of grazing in 4 of 7 years.

The differences in protein content and general quality of hay obtained under the different treatments are important. The hay from meadows grazed over the long spring season has in all years had a higher crude protein content than the hay from meadows grazed for short or medium periods. The quality of hay from the meadows pastured for short and medium periods has been rather comparable in most years of the test. What differences are noted between these two treatments seem if anything to favor the medium grazing period since protein content is highest for this treatment in 4 of 6 years in which direct comparisons can be made. Average protein content in the hay from the three treatments over the entire period was 8.13 percent for short season grazing, 8.25 percent for medium season, and 9.05 percent for long period spring grazing. Statistical tests show these differences to be highly significant.

Since the protein content of wild hays may definitely be the limiting factor in the value of such hays for winter feeding the higher protein content of the hay produced on the meadows grazed for the longest period may fully offset the difference obtaining in hay yields. The total protein in winter feeds from the pastures grazed for short, medium, and long periods obtained by multiplying hay yields by respective percentage protein values, amounts to 270, 276, and 274 pounds per acre, respectively. When total protein yield are considered (hay plus pasturage) the respective yields obtaining under the different treatments become 291, 311, and 349 pounds per acre--decidedly in favor of the longest grazing period.

Additional information which helps to explain the higher protein content and thus superior feed value of the hay from late grazed meadows and which should be considered in determining time of harvesting meadow hay was also obtained in this study. Cutting at proper stage of maturity is very important since these hays do not cure well on the stalk. Data from samples collected near beginning and end of the haying season proved that meadow forage left uncut after a certain stage of maturity had been attained, lost rapidly in protein content. The amount and rate of loss depends largely upon seasonal growing conditions. In seasons of ample irrigation water and timely summer rains wild-hay meadows continue to increase in gross yield up until late summer. Such a year was 1941 when hay yields between July 25 and September 3 increased by 18 percent. Conversely, crude protein was found to decrease 18 percent. The total acre yields of crude protein were thus approximately the same on July 25 and September 3. In 1942 when the water supply was less favorable, yields increased only 3 percent between July 25 and September 9 while protein content declined 35 percent. Average protein percentages over the two years for samples taken at beginning and end of haying season were 8.22 percent and 6.19 percent respectively, a proportionate decrease of 25.6 percent. This low protein in the overmature hay makes it a low-grade winter feed. Average hay yields for the ranch increased from 1.63 tons at beginning of harvest to 1.80 tons at the end of the harvest--an increase of only 10.4 percent.

Spring grazing on high-producing wild-hay meadows has, within limitations, additional significance to stockmen besides the resultant changes in yield and quality of hay alone. Many better livestock management practices such as protection of stock against late spring storms, use of breeding pastures, segregation of classes of livestock, and other desirable features can be better controlled on the home ranch than under open range conditions. Spring grazing of hay meadows as late as seasonal conditions permit and still maintain satisfactory hay yields, provides a means for giving spring ranges a much needed rest by an extension of the growing season of range plants. These benefits may have far-reaching effects on calf crop, gains made by calves and older beef animals, condition of stock in general, and total production of beef from ranch and range operations. All these items--better calf crop, better feed, and more rapid gains--are additive in their effects on production of livestock and livestock products. Because spring grazing of wild-hay meadows permits stockmen to secure these advantages in addition to relieving the grazing pressure on overgrazed and deteriorated spring ranges, this practice should be greatly extended in the Intermountain Region.

RANGE-WATERSHED CONDITION STUDIES

During the summer of 1942, Russell Croft of the Influence Division and Lincoln Ellison of the Summer Range Project joined in a study of the high summer ranges of Utah. The objectives were to work out procedures and methods for better evaluating the condition of the range resulting from grazing use. By "condition" I mean changes in plant cover, soil, and microclimate, changes that are occurring today and the rate and direction in which the changes are moving.

Why Such a Study Was Necessary

Although considerable progress has been made in the rehabilitation of badly depleted ranges since the creation of the Forest Reserves in the Intermountain Region, many ranges that have been under administration for over 30 years are still considered to be in unsatisfactory condition. Some of these ranges have not improved since being added to the national forests, while others are admittedly poorer today than when they were put under Forest Service management. This condition is not peculiar to the Intermountain Region.

The effort of both Administration and Research has been to rebuild deteriorated ranges and to maintain the values of those which were in satisfactory condition. Insofar as depleted ranges still exist and others are deteriorating on the national forests, to that extent have we failed in our management program.

Before these situations can be remedied in the future it is essential to learn the reasons for our failures in the past. Regional Forester Woods has often asked the reasons for the existence of depleted ranges either as reported to him or of which he has made personal investigation. The Washington Office has made annual requests to the regions to explain why certain ranges continue in unsatisfactory condition. The answers most commonly given are:

1. Public pressure on rangers and supervisors.
2. Failure of Regional Office to support a proposed adjustment urged by a supervisor, either because of disagreement as to its necessity or because of political or public pressure.
3. Similar failure of support by the Washington Office.
4. Failure to use management plans developed from surveys or failure to make range surveys.
5. Overstocking during last war.
6. Increase in numbers of big game.
7. Failure to apply to management, knowledge already available.
8. Failure in judgment--incorrect interpretation of condition of the range.

All these reasons may have contributed to a continuation of unsatisfactory conditions. However, the relative importance of the eighth reason--our inability to interpret correctly the affects of past and present use on vegetation and soil, or to perceive the rate and trend of changes--has not been fully recognized by Administration or Research and is responsible for at least a part of our failures.

This does not mean that Administration has not been aware of the existence of deteriorated ranges or that they have failed to recognize that ranges have broken under their management. We have all known that in many cases reductions in livestock were necessary and we know that if reductions had been made when such need was first recognized our range lands would be today in much better condition and our management and public relation problems much simpler. All, I am sure, recognize this. However, field demonstrations, studies, inspections, and conferences conducted during the past few years suggest very strongly that lack of knowledge--inability to properly judge range conditions--has played an important part in our failures. This experience combined with the contradictory official pronouncements of range conditions on the national forests in general, together with the inconsistencies of periodic inspection reports covering the same range, lends support to the belief that even if reduction in number of livestock had been made we still would have today a considerable number of ranges on which this problem of proper stocking and management would not be solved.

If we had possessed adequate knowledge one would think 35 years a sufficient time to have rehabilitated most of the ranges under our jurisdiction. The fact that we have been reducing livestock periodically on some of the ranges during the period of our management and that further reduction is still necessary suggests that in many instances past adjustments have not been made with a fundamental knowledge of the requirements of the range.

A more critical and elusive problem even than rehabilitation of deteriorated ranges is that of maintaining those considered to be in good condition. Our management record on certain ranges points to the fact that serious plant and soil changes can take place before we are aware that deteriorating processes have been set in motion. Past history of range retrogression and inconsistencies in appraisals of range condition today argues strongly for additional knowledge that will enable us to detect changes in their incipient stages so that adjustments in management can be made in time to avert serious damage to the soil and plant cover.

There is much confusion of thought and opinion as to what these requirements are. It is not uncommon to have rangers, or even supervisors, report improvement of the ranges year after year, even to the complete attainment of objectives and then to have a man transferred to that forest from elsewhere report immediately upon examination that the range is in unsatisfactory condition and that further reduction of livestock is necessary.

This difference in judgment is by no means limited to rangers. During the last summer three groups of supervisors, accompanied by Regional Office men and Experiment Station personnel, examined a number of forest ranges in this region attempting to diagnose their condition. In each case wide differences of opinion were found to exist, sometimes to the extent that diametrically opposite conclusions as to range conditions were reached.

Complexity of the Range-Watershed

There appears to be three principal reasons for the difficulties encountered in evaluating range conditions: (1) failure to recognize the complex nature of the range, (2) inadequate and faulty use of criteria, and (3) research results have not been sufficiently applicable to the task of evaluating range conditions.

All of us have not understood and appreciated the fact that any part of the "range," no matter how small, is a complex, the result of an intricate interplay of forces and factors, both biological and physical that have been operating over a very long period of time and that use of the range results in changes in these forces and factors. These concepts are not commonly understood. Moreover range men are unlikely to agree as to what constitutes range improvement. Is a range improving when the density of vegetation increases or only when density increase involves plants desirable to the class of stock grazed? What constitutes improvement from the soil point of view? Is it a slowing of the rate at which soil is being lost? Is it complete stoppage of visible loss? Does it require the actual building of soil? Or does improvement imply complete stoppage of accelerated erosion, by accumulation of litter on the surface, and an increase in plants which are relished by the class of stock grazed?

Mountain range consists not of one complex, but many. Here diversity, both physical and biological, reaches its height. Great differences in climate, aspect, degree of slope, soil, infiltration capacity and erosion potential, as well as in vegetation, occur within the boundaries of a single allotment, or even a fraction of an allotment. Add to this complicated set-up a short grazing season, the necessity for utilization during the growing season and the inevitable differences in livestock distribution and utilization from place to place, and it is little wonder that problems of mountain-range management should be difficult ones. Compared to them, the problems of management on valley ranges, with their gentle terrain and extensively uniform soils and plant types, seem almost simple. Obviously, what might be an accurate appraisal of the condition of one part of this complex summer range may not be at all applicable to another part, and a criterion having significance in one specific situation may be entirely misleading in another.

Faulty Use of Criteria

Frequently we use criteria wrongly. It may be observed, for example, that plant cover density on a certain range has increased from 0.1 to 0.2--a 100 percent increase. If we conclude, without aid of other related facts, that this criterion indicates range improvement, a condition twice as good as formerly, we may be wrong. We might have found upon further examination that the density increase has not materially decreased soil loss. Then again it has been determined that plant vigor can be maintained under grazing if a certain percentage of the stems and leaves are not consumed. Correct utilization is often determined with satisfactory results by using this principle. However, considering the diversity in mountain range, there may be no relationship between the amount a plant can be grazed without losing vigor and the maintenance of satisfactory range conditions. It is not enough to know the particular degree of utilization that plants of a certain species can endure. That is only one part of the story. The interrelations of this species with all the other species in the plant cover, the interrelations of vegetation and soil, and of vegetation, soil, and site must be considered at the same time. Owing to factors other than forage utilization, such as trampling, the functioning of the complex may be upset and erosion may be induced which would destroy the whole range.

This fact was demonstrated on one of the watersheds at the Great Basin Branch Station. Area B, having been protected from grazing for a number of years, was yielding a certain rather moderate amount of run-off and silt from storms precipitated on the area. Sheep were turned in the area to reduce the plant cover so that the effect of utilization on run-off and erosion could be measured. During the second year of grazing and before the density of cover had been materially reduced, a storm of normal proportions occurred which produced run-off sufficient to severely erode the soil. This erosion was not due to the reduction in plant cover but principally to another factor--the reduction in infiltration capacity due to trampling by sheep.

The experience demonstrated clearly that accelerated erosion can occur before cover is destroyed, and that erosion alone, rather than forage utilization, can destroy plant cover. Other observations have demonstrated just as clearly that range once disturbed may keep on deteriorating even without grazing.

Again, the principle of plant succession and the concept of climax species provide important criteria for judging range, but under certain conditions their application may give an entirely false idea of range improvement. To cite one example of many at hand, the so-called climax species, such as wheatgrass on the high ranges of the Manti National Forest, often occur as the dominant far below the climax, on denuded clay banks, and even on erosion pavements.

The appearance of grass and other herbaceous vegetation in gully bottoms is most generally used as a criterion of range improvement. In some instances this may be a correct deduction, but in others it is fallacious. Local circumstances may permit the temporary establishment of a luxuriant vegetation in gully bottoms even on actively eroding range and under such circumstances run-off and erosion may not be decreased but only diverted.

In a word, no criterion can be used safely if it is used mechanically. It must be correlated with all other available criteria and applied with a realistic appreciation of the factors which operate within the range complex.

Research and the Range Problem

Results from research have not been sufficiently applicable to the task of evaluating directly, range condition. Facts and principles determined for one set of conditions in a specific environment do not always give the right answers when used to evaluate a range with different characteristics. This is not because the findings of research have not been valid nor because the facts sought for were not important. Actually, past research has provided a fund of knowledge without which progress on certain fundamental phases would be impossible. This knowledge has been accumulated through the patient efforts of workers in the Department of Agriculture, State experiment stations, colleges, universities, and privately endowed institutions operating in the various physical and biological fields. Their discoveries constitute an invaluable asset.

We are beginning to recognize, however, that controlled experiments in specialized fields give results that require synthesis and adaptation to the variable environment of a sheep or cattle range. On the range, any single factor discovered does not function independently: it is but part of a biological and physical complex, and in many cases will not itself give the manager the information that will enable him to judge his range. The range complex as a whole and the interrelations of its components must also be understood. This requires a skillful synthesis of all the factors discovered by past research and management experience arranged and correlated by study of the ecological complex in the field.

Work of Past Year

One gap in our knowledge which needs filling is that of ascertaining criteria by means of which range condition may be more accurately gaged--criteria which will tell us what is happening now to a range as opposed to those criteria which tell us what has happened after damage is irreparably done.

This lead was followed up during the past summer, using as a starting point those "indicators of range condition," the best available criteria now in use. A study of the application of these criteria in the field led to the realization that both the criteria now in use and any modifications

of them or any new criteria which might be developed could only be used if the basic ecological facts were properly understood. Moreover, basic ecological knowledge as to "how the range works" is probably a prerequisite to the development of new criteria. A careful analysis of this problem leads us to the belief that the most promising approach would be that in which the workings and interrelations of the range-watershed complex are studied under field conditions synthesizing these observations with facts already known. As I have already pointed out, we have at this time a considerable fund of knowledge build up by past research and management experience which can be applied in this effort to ferret out further information.

Croft and Ellison have spent most of the past field season on the higher parts of the Manti, Uinta, Fishlake, Powell, Dixie, and LaSal Forests. Stewart spent a few days with them on the Manti and I spent a few days with them on the Powell.

The approach to this study have been to endeavor to grasp the interrelationships of each range complex, combining a close scrutiny of its smallest parts with an appraisal of its grosser relations. Every known criterion was tested both before and after grazing, in an attempt to piece all the signs together so as to understand what has been taking place during the past several years. In this process, the facts were observed, hypotheses were formulated and tested, and conclusions were drawn, as best the job could be done under the limitations imposed, right in the field.

This is the approach which, for want of a better term, I have referred to as "observational." It does not entail permanent plots or installations, although use was made of these wherever possible.

The data collected during the past summer--field notes and photographs--have now been assembled for reference in one large volume, and the soil samples collected have been analyzed.

The results of the study are being put up in two reports. One is to be in the form of a handbook for the guidance of field men in the use of criteria. The bulk of the effort so far this winter has gone into this report, which, it is hoped, will soon be completed. The other report, addressed to the Director, will be concerned with facts observed relating to present range management and range research practice and policy.

As part of their work in studying criteria, Croft and Ellison gathered material on the ecology of one of the higher plateaus which would form a considerable contribution on the little-known subject. This they thought would probably be acceptable to ECOLOGICAL MONOGRAPHS. However, the preparation of this article has been postponed indefinitely in view of the higher priority of the range-watershed criteria study proper.

Work for the Coming Year

Detailed plans for next summer's work under this project cannot be made until after the results of last year's investigations are written up and discussion had with Administration. It will be proposed, however, that our so-called "Guide to Range Conditions" be tested in the field. Two allotments will be selected--poorest and best--on each of four forests to be studied before and after grazing. It will be recommended that someone from Range Management together with the ranger or supervisor of the particular forest under investigation participate in the observations.

The object will be threefold:

1. To test the developed procedures and criteria.
2. To demonstrate our suggested methods of approach and application of criteria; and
3. To acquire new facts and concepts.

FOREST AND RANGE INFLUENCE INVESTIGATIONS

Water in Utah has gone to war. The State's strategic location has brought to it some of the nation's biggest wartime industries, such as steel mills, ordnance plants, hospitals, and supply depots for the Army, Navy, and Air Forces, which has created an acute water problem.

The populations of some counties have doubled in 2 years and in the Ogden area alone 27,000 additional workers are needed by April 1. The State's third largest city, a military community, was not in existence a year ago. In a region already limited in its water resources such a huge development of industrial activities has forced our attention to water.

Studies at the Wasatch Branch Station were designed to determine the effect of vegetation and its utilization by livestock on the characteristics of streamflow. These studies are being made on Farmington Creek and 11 of its tributaries--5 south-facing and 6 north-facing watersheds. Stream gaging and climatic measuring stations have been established on the experimental watersheds. Vegetation and soil was extensively inventoried prior to 1940. During the past year we were able to maintain our stream gaging and climatic measurements at a satisfactory level or calibration.

All other work at the branch station has been discontinued for the duration. The need for water and waterflow control at this station is so vital to the war effort and to the continuation of the industrial development after the war that we feel more keenly than ever the need to continue stream flow and climatic measurements with as little interruption as possible. With this information we can contribute to watershed management and improvement programs that will promote the safety and stability of a water supply for agriculture and the war industries. At the same time we will be accumulating information necessary to the prosecution of a post-war watershed-rebuilding program.

At the Great Basin Branch Station forest influence studies were expanded in 1940 and 1941 to include the study of stream flow phenomena on Ephraim Creek. Stream gaging stations have been constructed at the mouth of Ephraim Creek and Bluebell Bridge and on five small tributaries in the recharge zone above 9,000 feet in elevation. The principal objectives of this study are to determine the effects of upstream engineering work and range management practices on the yield and quality of water. During the past year a minimum of stream flow and climatic records were collected for calibration purposes.

Work for the Coming Year

The major effort under the Influence Project will be the continuation of the range-watershed condition studies carried on cooperatively with Summer Range research, as described in a special section under that heading. The only other work contemplated is the continuation of the stream flow and climatic records on Farmington Creek at Wasatch Branch Station and Ephraim Creek at the Great Basin Branch Station.

RANGE ECONOMICS

The work of this division has been shifted entirely to the furtherance of the Department's food production program. A perusal of the list of Roth's activities for the past year will indicate the completeness of our conversion to the war effort as well as the scope and character of the work undertaken.

Assisted in the preparatory planning of 1943 production goal estimation work in Utah.

Handled the field work and report for one of the four production areas in Utah.

Assisted in writing the Utah production goals planning report for the State and its presentation to the State Agricultural Planning Board.

Wrote the Utah section of the southwestern Intermountain region report on 1943 production goals, and wrote the report on problems and plans for attainments of livestock goals in this region. (Utah, Colorado, New Mexico, and Arizona.)

Prepared data on range livestock numbers, trends, and production rates for the states of Idaho and Nevada for the 1943 production goal planning program.

Broke down the 1943 livestock and poultry goals for the State of Utah into the county goal figures for the State USDA War Board.

Compiled data for the Utah War Board on number of Japanese laborers used in 1942 agricultural production in Utah.

Compiled data on 1942 prices and production trends of various agricultural products for use of the Utah War Board.

Analyzed plans for securing data on sawmill operations in Region 4 for Timber Management R-4, in connection with WPB survey and suggested improvement in procedures.

Assisted in the preparation of data for use in popular articles for publishing the 1942 agricultural production goals, particularly range livestock, and methods for attaining these goals.

Work for the Coming Year

The division of Range Economics is qualified to supply greatly needed statistical and economic information in range livestock production programs. Its services to the War Boards of the three Intermountain states and to the Forest Service should continue.

PUBLICATIONS

In Print

Croft, A. R., Lowell Woodward, and Dean Anderson. Measurement of accelerated erosion of range watershed land. Jour. Forestry, Feb. 1943.

Ellison, Lincoln. Trends of forest recreation in the United States. Jour. Forestry, Aug. 1942.

________________. A comparison of methods of quadratting shortgrass vegetation. Jour. Agr. Res. 1942.

Hull, A. C., Jr., and J. F. Pechanec. An extension of range for blue grama. Ecology. July 1942.

Plummer, A. Perry. The germination and early seedling development of twelve range grasses. Jour. Soc. Agron. Jan. 1943.

Robertson, Jos. H., and H. Lloyd Weaver. A new tetraploid from Nevada. Torrey Bot. Club Bull. June 1942.

Roth, Arthur H. Jr. Veal calves or dairy steers. Utah Farmer, Dec. 1942.

________________ and A. Perry Plummer. Increasing livestock production and profits by developing good spring range. Intermountain Tech. Note #2. Sept. 1942.

Saunderson, Mont H. Cattle production and marketing in the West. American Cattle Producer. Mar. 1942

________________ Idaho national forests and the range sheep industry of southern Idaho. Idaho Forester. 1942.

Submitted for Publication

Ellison, Lincoln. What is range improvement? Ames Forester.

Pearse, C. Kenneth, and A. C. Hull, Jr. Some economic aspects of reseeding range lands. Jour. Forestry.

Robertson, J. H. Seasonal root development of sagebrush (*Artemisia tridentata* Nutt.) in relation to range reseeding. Ecology.

Stewart, George, et al. Forage production as related to livestock management in northeastern Nevada. Univ. Nev. Bull.

Woodward, Lowell, Infiltration capacities of some plant-soil complexes on Utah range watershed lands. A.G.U.

Manuscripts that will be finished by June 1 and suggested outlets

Clark, Ira. Suitability of volume-height tables for estimating the degree of range forage utilization. Jour. Forestry.

Croft, A. Russel. Water has gone to war in Utah. Special feature, Salt Lake Tribune.

Hull, A. C., Jr. Grazing reduces vigor of young crested wheatgrass. Wool Grower.

____________ and C. Kenneth Pearse. Reseeding Idaho Range Lands. Mimeo.

Hutchings, Selar S. and George Stewart. Good grazing practices on winter range yield greater profits to sheep operators. U.S. Dept. Agr. Circular.

Pearse, C. Kenneth and A. C. Hull, Jr. Range reseeding - does it pay? Producer or Cattleman.

Pechanec, Jos. F., George Stewart, and G. Pickford. Sagebrush burning--Good or Bad. U.S. Dept. Agr. Farmers' Bull.

Plummer, A. Perry, R. M. Hurd, and C. Kenneth Pearse. Reseeding Utah range lands. Mimeo.

Robertson, Jos. H. and C. Kenneth Pearse. Reseeding Nevada range lands. Mimeo.

Stewart, George and Ira Clark. Spring grazing of wild-hay meadows increases forage production. Producer.

____________ and Boyd Leonard. Importance of adequate range forage in livestock production.

STATION PERSONNEL - C. Y. 1942

ADMINISTRATION

Reed W. Bailey	Director
Walter E. Mann	Sr. Administrative Assistant
Marguerite A. Israelson	Sr. Clerk
Herbert Burrell	Clerk
Leona H. O'Donnell	Asst. Clerk
Ann P. Bergquist	Jr. Clerk-Steno.
Emma Martin	Jr. Clerk-Steno.
Elaine Nelson	Jr. Clerk-Steno.

RANGE INVESTIGATIONS

Grazing Management

George Stewart	Sr. Forest Ecologist
Lincoln Ellison	Range Examiner
Selar S. Hutchings	Assoc. Forest Ecologist
Joseph F. Pechanec	Assoc. Forest Ecologist
Ira Clark	Asst. Conservationist
Jack Major	Jr. Range Conserv.
Earl L. Yersin	Asst. Agricultural Aid
Paul E. Hansen	Jr. Field Assistant

Artificial Reseeding

George Stewart	Sr. Forest Ecologist
C. Kenneth Pearse	Conservationist
Alvin C. Hull, Jr.	Asst. Forest Ecologist
A. Perry Plummer	Asst. Forest Ecologist
Joseph H. Robertson	Asst. Forest Ecologist
Richard M. Hurd	Jr. Range Examiner
Lael R. Harrison	Agricultural Aid
J. Pershing Blaisdell	Asst. Agricultural Aid

FOREST AND RANGE ECONOMICS

Arthur H. Roth, Jr.	Assoc. Agr. Economist

FOREST AND RANGE INFLUENCES

Influence of Natural Revegetation on Stream Flow

George W. Craddock	Sr. Range Examiner
A. Russell Croft	Conservationist
James P. Thorne	Asst. Soil Technician
Richard B. Marston	Jr. Range Examiner
Alden Blain	Asst. Agricultural Aid

FOREST PRODUCTS SURVEY

War Production Board

Reed W. Bailey	Director
Edwin L. Mowat	Asst. Silviculturist

FLOOD CONTROL SURVEYS

Boise River and Sevier Lake Surveys

George W. Craddock	Sr. Range Examiner
Cleve H. Milligan	Hydraulic Engineer
Harold H. Price	Assoc. Range Examiner
Lowell Woodward	Jr. Range Examiner
Kenneth M. Daniels (Detail R-4)	Forest Ranger

FOREST AND RANGE BIOLOGY

Clarence M. Aldous (Cooperation Fish and Wildlife Service)	Assoc. Biologist

FINANCIAL BUDGET FOR PORJECTS FOR FISCAL YEAR 1943

1. Direct and indirect costs by financial projects.

	Indirect project costs (overhead)	Direct project costs	Total costs
Range Investigations	$ 12,110	$ 47,623	$ 59,733
Forest Economics	2,615	7,916	10,531
Forest & Range Influences	2,240	13,084	15,324
Flood Control Surveys	2,400	12,124	14,524
Forest Products Survey (WPB)	-	4,000	4,000
P&M Maintenance, R-4	-	4,100	4,100
P&M Range Management, WO	-	1,590	1,590
TOTALS	19,365	90,437	109,802

2. Distribution of direct costs by main projects.

Division and work project	Cars mainte-nance & new	Scientific equipment & project supplies	Travel expenses other than cars	Salaries		Total
				Regular	Temporary	
RANGE INVESTIGATIONS						
Grazing Management	$ 600	$ 2,500	$ 1,300	$16,890	$ 2,115	$23,405
Artificial Reseeding	800	2,800	1,700	17,100	1,818	24,218
FOREST ECONOMICS						
Range Economics	350	570	900	5,596	500	7,916
FOREST INFLUENCES						
Water Behavior and Run-off	600	1,709	1,000	8,375	1,400	13,084
FLOOD CONTROL SURVEYS						
Sevier	100		200	2,800		3,100
Boise	400		1,600	7,024		9,024
FOREST PRODUCTS SURVEY						
Survey	200		500	3,300		4,000
TOTALS	3,050	7,579	7,200	61,085	5,833	84,747